DETAILED ACTION

Status of Claims

1. The amendment filed 11/12/2009 has been entered. Claims 1, 3, 6, 8-14, and 22-25 remain pending. Claims 23-25 are new.

2. The previous 35 USC 112 rejection, second paragraph, of claim 1 is withdrawn in light of Applicant's amendment to claim 1.

3. The previous 35 USC 112 rejection, second paragraph, of claim 20 is moot directed to a now canceled claim.

4. All previous 35 USC 103(a) rejections of claims 1-3, 6-14, 19, 21, and 22 over Smiljanic *et al.* (*Chem. Phys. Lett.*, 356, 2002, 189-193), Tsantrizos *et al.* (5,395,496), Tsantrizos *et al.* (5,147,998), Matsumoto *et al.* (JP 07061803) and Cohen *et al.* (5,993,697) are withdrawn in view of a new rejection (See *New Grounds of Rejection*), which better addresses the current as amended claims.

Specification

5. The amendment filed 11/12/2009 is objected to under 35 U.S.C. 132(a) because it introduces new matter into the disclosure. 35 U.S.C. 132(a) states that no amendment shall introduce new matter into the disclosure of the invention. The added material in paragraph [0005] which is not supported by the original disclosure is as follows: "the resulting plasma stream containing carbon, carrier gas and metal vapor entering the quenching zone of carbon nanostructure formation, whereupon metal catalyst nanoparticles acting as nucleation sites and catalyst for the growth of carbon nanostructures are generated *in situ* in a diameter range of from about 2 to about 30 nm from the metal catalyst vapor, which with atomic carbon from the carbon

containing substance, form such structures in a diameter range of from about 2 to about 30 nm, which carbon nanostructures are then collected" and "using the cooling of the plasma stream above 10^7 °C/s produced by the carbon-containing substance and carrier gas feed, and by a supersonic shock created at an exit of the nozzle or the provision of an expansion in the nozzle internal diameter…".

Specifically, support for the for diameter range of the metal catalyst nanoparticles produced *in situ* (*i.e.* from about 2 to about 30 nm) is not found in the original specification. The only written support found for the diameter range was found in paragraph [0029] of the published US pre-grant application: "One important aspect of the present application is the ability of the method to generate the nanometer sized metal particles." Nanometer sized particles can be interpreted as a diameter range of 1 to 100 nm, not 2 to about 30 nm. Figure 15 identifies catalyst particles; however, it is uncertain if a range of 2 to about 30 nm can be extrapolated from the figure given the quality and a scale bar of 1000 nm. Support was found for the recitation of the nanostructures themselves being between 2 to about 30 nm (para 0028).

Furthermore, support for the cooling of the plasma stream above 10^7 °C/s was not found in the original specification. The Declaration of Dr. Jean-Luc Meunier provides the calculations necessary for determining the quench rate (bottom of p. 5 though middle page 6). The Specification can be amended to include the general equations and need not necessarily show the calculations. Unfortunately, since Applicant did not originally disclose these ranges, any ranges calculated outside of the disclosed parameters in the original specification is considered new matter not supported by the original Specification.

Claim Objections

6. Applicant is advised that should claim 1 be found allowable, claim 24 will be objected to under 37 CFR 1.75 as being a substantial duplicate thereof. When two claims in an application are duplicates or else are so close in content that they both cover the same thing, despite a slight difference in wording, it is proper after allowing one claim to object to the other as being a substantial duplicate of the allowed claim. See MPEP § 706.03(k).

Claim Rejections - 35 USC § 112

7. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

8. Claims 1, 24, and 25 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

Specifically for claim 1 (step d), claim 24 (step c), claim 25 (step d) no support was found for the diameter range of the in situ metal catalyst nanoparticles from about 2 to about 30 nm. Additionally for claim 25 (step d), no support is expressly found for the value of 10^7 °C/s. Applicant is required to cancel the new matter in the reply to this Office Action.

New Grounds of Rejection

Claim Rejections - 35 USC § 103

9. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

10. Claims 1, 3, 6, 8-12, and 22-24 rejected under 35 U.S.C. 103(a) as being unpatentable over Tsantrizos *et al.* (5,395,496), hereafter Tsantrizos #1, in view of Tsantrizos *et al.* (5,147,998), hereafter Tsantrizos #2, Smiljanic *et al.* (*Chem. Phys. Lett.*, 356, 2002, 189-193), and Matsumoto *et al.* (JP 07061803).

Regarding claims 1 and 24, Tsantrizos #1 discloses a process for the synthesis of fullerenes, the method comprising the steps of:

a) providing a high enthalpy metal electrode generated direct current thermal plasma torch (abstract) having a plasma forming gas and nozzle attached thereto, the torch being connected to a cooled reactor having a quenching zone downstream of the plasma torch for the formation of fullerenes (Fig. 1);

b) selecting a torch power at a level of from about 30kW up to a multi-megawatt level, selecting a flow rate for the plasma forming gas feed, and selecting the reactor pressure (col. 5, Example 1); and

c) providing a feed of carbon containing substance and a carrier gas at a selected flow rate to the plasma stream in the vapor state (col. 5, Example 1).

Tsantrizos #1 does not teach a cooled nozzle (from step a), selecting a catalyst metal and providing a catalyst metal to the plasma stream (from step b), and a resulting plasma stream containing carbon, carrier gas, and metal vapor, wherein the in situ metal catalyst particle range

from about 2 to about 30 nm and the carbon nanostructures range in diameter from about 2 to about 30 nm.

Tsantrizos #2 more completely describes the same torch as Tsantrizos #1, incorporated by reference therein (Tsantrizos #1, col. 4, lines 64-67). Tsantrizos #2 teaches the cooling system cooling the electrode. It would have been obvious to one of ordinary skill in the art at the time of invention to use a cooling system to keep the system from overheating and melting the electrodes (Tsantrizos #2, col. 4, lines 23-43).

Smiljanic teaches synthesis of single wall carbon nanotubes by an atmospheric pressure plasma jet. Smiljanic teaches selecting a catalyst (*e.g.* ferrocene) and providing the catalyst precursor to the plasma stream. It would have been obvious to one of ordinary skill in the art at the time of invention to use a catalyst since it is known to use a metal (catalyst) for the production of carbon nanotubes (Smiljanic, p. 190, col. 2, line 10-12).

Furthermore, it would have been obvious to one of ordinary skill in the art at the time of invention to use a DC thermal plasma torch to make both fullerenes and SWNT motivated by Matsumoto. Matsumoto teaches the synthesis of both fullerenes and carbon nanotubes using a high-frequency plasma (abstract), equivalent to a thermal plasma torch. One skilled in the art would have been motivated to make carbon nanotubes due to their unique electronic and physical properties.

Together, Tsantrizos #1 and Smiljanic teach the resulting plasma stream contains carbon, carrier gas, and metal vapor into a quench zone (the furnace and the metallic plate, Smiljanic Fig 1 or collecting plate **14** of Tsantrizos #1) for nanoparticle formation. The diameter of the aggregates (*in situ* metallic catalyst nanoparticles) ranges from 10 to 100 nm which overlaps

Applicant's claims of about 2 to 30 nm (Smiljanic, page 191, col. 2, lines 6-7). See MPEP 2144.05 for Overlapping Ranges. Regarding the diameter range of about 2 to 30 nm for the actual nanostructure, Smiljanic teaches diameters of 1.5 nm; however states higher temperature (such as those achieved by Tsantrizos #1, enables the formation of tubes with larger diameters (Smiljanic, p. 192, col. 1, lines 1-4).

Regarding claim 3, Tsantrizos #1 teaches helium (col. 5 Example 1) and Smiljanic teaches argon (p. 190, Fig. 1) as carrier and plasma forming gases.

Regarding claim 6 and 22, Tsantrizos #1 teaches carbon halides such as C_2Cl_4 vaporized before injection (col. 4, lines 41-45).

Regarding claims 8-10, Smiljanic, Tsantrizos #1, and Matsumoto are silent as the electrode material of construction.

Tsantrizos #2 teaches the same high enthalpy plasma torch as Tsantrizos #1. The electrode may be tungsten (col. 3, lines 44-50).

It would have been obvious to one of ordinary skill in the art at the time of invention to use tungsten motivated by the fact that tungsten is a suitable refractory material for electrode construction (col. 3, lines 44-54) due to tungsten's high boiling point.

Regarding claim 23, Tsantrizos #2 teaches the electrode further comprises copper (col. 2, lines 43-45).

Regarding claims 11 and 12, Smiljanic teaches, as described in the experimental section, the carbon-containing gas and catalyst are introduced together and each controlled independently (page 190, col. 2). The ferrocene vapor is obtained by a temperature-controlled sublimation and the carbon-containing gas controlled separately within the specified flow ranges.

11. Claims 13 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over, Tsantrizos #1, Tsantrizos #2, Smiljanic, and Matsumoto as applied to claim 1 above, and further in view of Cohen *et al.* (5,993,697).

Regarding claims 13 and 14, Tsantrizos #1, Tsantrizos #2, Smiljanic, and Matsumoto do not teach the catalyst is derived from at least one metal powder injected into the outlet flame of the torch.

Cohen, directed towards making carbon materials, teaches the use of a plasma arc and catalytic particles in powder or other forms and injected directly into the arc (col. 14, lines 12-15). It would have been obvious to one of ordinary skill in the art at the time of invention to use a metal powder catalyst to produce metallic carbon useful in optical devices (col. 14, lines 43-47).

Response to Amendment

12. The declaration under 37 CFR 1.132 filed 11/12/2009 to Dr. Meunier is insufficient to overcome the rejection of claims 1-3, 6-14, and 19-22 based upon the applied 35 U.S.C. 103(a) rejections as set forth in the last Office action because the declaration is not commensurate in scope with the claims and certain features of the invention upon which applicant relies are not recited in the rejected claims. For example, *inter alia*, Applicant states the carbon containing gas is injected only within the nozzle and is not present inside the plasma torch (Meunier Declaration p. 4). This limitation is not recited in the claims as currently presented.

13. The declaration under 37 CFR 1.132 filed 11/12/2009 to Dr. Boulos is insufficient to overcome the rejection of claims 1-3, 6-14, and 19-22 based upon the applied 35 U.S.C. 103(a) rejections as set forth in the last Office action because the declaration is merely opinion and fails to set forth facts.

Response to Arguments

14. Applicant's arguments filed 11/12/2009 have been fully considered but they are not persuasive. Specifically regarding new claim 25, Applicant argues support for the language is found in the prior art; however, such language appearing the claims needs be appear in the Specification. See 3rd paragraph of Section 5 of current Office Action above.

15. Applicant argues the combination of Tsantrizos #1 and Smiljanic because the reference to Tsantrizos #1 uses the torch for a homogenous chemical reaction. This argument is not persuasive because Figure 1 to Tsantrizos #1 illustrates a zone between the torch and the collection stage where cooling occurs and interpreted as the quench zone downstream of the plasma torch for the formation of carbon nanostructures as claimed. Similarly, the zone in Figure 1 to Smiljanic could be interpreted in the same light. However, Tsantrizos #1 and Smiljanic do not disclose a specific cooling rate above 10^7 °C/s due to the carbon containing substance and carrier gas.

16. Applicant also argues the combination above in view of Matsumoto. Matsumoto is used as motivation to show the synthesis of both fullerenes and carbon nanotubes is possible using a thermal plasma torch. Although the actual process condition may be difficult (Applicant's Remarks p. 15), it is not outside of the skill of one skilled in the art to appreciate that the formation of both fullerenes and carbon nanotubes are possible with the same system.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Carlos Barcena whose telephone number is (571) 270-5780. The examiner can normally be reached on Monday through Thursday 8AM - 5PM EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jerry Lorengo can be reached on (571) 272-1233. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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